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APOLLO EXPERIENCE REPORT - DATA MANAGEMENT FOR POSTFLIGHT ENGINEERING EVALUATION

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16. Abstract

TheApollo management of data for postflight engineering evaluation is described. The sources of Apollo telemetry data, the control of data processing by a single data team, the data techniques used to assist in evaluation of the large quantity of data, and the operation of the data team before the mission and during the evaluation phase are described. The techniques used to ensure the output of valid data and to determine areas in which data were of questionable quality are also included.

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DATA MANAGEMENT FOR POSTFLIGHT ENGINEERING EVALUATION

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SUMMARY

Apollo data management was based on the experience gained in the Gemini Program and was modified to use advantageously the abundance of real-time data available on the Apollo lunar flights. The central data management team provided the single point of control for Apollo data reduction. An in-depth reduction of all flight data was neither economical nor practical because of the large amounts of data generated on the later Apollo flights. The concepts developed by the data team were as follows.

1. To use the data from early missions to establish the characteristics that define normal system operations

2. To develop a system to afford the analysts a quick look at the overall mission data throughout the remaining Apollo flights

3. To perform an in-depth reduction of data for those areas in which additional analysis was required

To fulfill these objectives, the data team used quick-look techniques to identify areas needing more analysis and a computer to scan data and to remove superfluous data (bandpass). Standard outputs were developed so that production methods could be used to process data.

The method of operation used by the evaluation team began before the mission with the planning of the data reduction. During and after the mission, the analysts reviewed the quick-look data and submitted requests for additional data. The data team consolidated these requests, assigned priorities, and submitted the consolidated requests to a processing organization. The data were then processed, validated, and delivered to the user.

INTRODUCTION

The experience gained during the Gemini Program in data management for mission evaluation purposes was applied to the Apollo Program. Because of the large mass of data acquired during Apollo missions and the need to evaluate these data, a method was developed to review all data rapidly and then carefully select those data that required in-depth processing. In addition, the Apollo data management system accommodated many users that included approximately 12 NASA spacecraft systems analysis groups and two major contractors, each with their own systems analysts. This report discusses the methods used in processing Apollo engineering data and the activities of a central data management team in making the data available for mission analysis on a timely and economical basis. The computer terms used in this report are defined in the appendix.

FLIGHT DATA MANAGEMENT

Data Sources

Two types of data sources are of interest to the data processor: the spacecraft data sources and the ground data systems.

The primary source of spacecraft data was the operational telemetry system. The characteristics of the basic pulse code modulation (PCM) system used in both the command and service module (CSM) and the lunar module (LM) are given in table I.

TABLE I.- CHARACTERISTICS OF THE BASIC PCM SYSTEM

Characteristic	Mode of operation	
	High bit rate	Low bit rate
Bit rate, kbps	51.2	1.6
Bits/word	8	8
Words/frame	128	200
Prime frame rate, frames/sec	50	1
Subframe rate, subframe/sec	1	0

Data could be transmitted in real time in either of these modes. The CSM could record data for later transmission to the Earth. The LM did not contain a recorder but could transmit low bit rate data to the CSM recorder. Other Apollo telemetry data sources were the CSM flight qualification tape recorder and the LM developmental flight instrumentation package. The flight qualification tape recorder was a supplemental data system for supplying data on the launch and entry conditions. The developmental flight instrumentation system provided supplemental data to verify the proper systems operation during the two initial LM flights, the Apollo 9 and 10 missions. Data reduction from these systems was a short-term task that required special handling.

After being received at the ground station, the data were handled in two different ways: (1) the data were routed back to the NASA Lyndon B. Johnson Space Center (JSC) (formerly the Manned Spacecraft Center (MSC)) to assist in the operational control of the mission, and (2) the data were recorded on magnetic tape for shipment to a reduction facility. The data for operational control were transmitted from the Manned Space Flight Network (MSFN) sites by high-speed data lines. Because of limited bandwidth, the high-speed data lines available would not accommodate all spacecraft telemetry data. Two methods were used to decrease the amount of retransmitted data. In the first method, data were thinned by reducing the sample rate. In most cases, selected measurements were transmitted to MSC at one-tenth the normal sample rate. The second method was to transmit only those data that were of most interest during a particular mission phase. Thus, planned sets of measurement/sample-rate formats were used. Each of these formats was used for a particular mission activity or function. For example, a format containing mostly CSM data was transmitted during translunar coast, and a format containing both LM and CSM data was transmitted in lunar orbit.

Data Management Team

The Apollo data were managed by a central data management team that was established to control the reduction of all mission data. The data team was a concept that had proved effective during the Gemini Program. The major functions of the central data management team that contributed to the success of the Apollo mission data task are explained in the following paragraphs.

To eliminate redundancy in data processing, requests from several users were combined into one request to the processing facility, and the capabilities of the computer system were used fully. For example, computer systems in use could process all spacecraft telemetry measurements in a single computer run. The computer time required to process all measurements as compared to processing only a few was negligible. Because experience had indicated that more than one person was usually interested in data from a particular event, an analyst's request for particular measurements resulted in a data management team request for all measurements for that time period.

Data were only processed when required for analysis. The data team, a part of the mission evaluation team, was staffed with engineers who understood the principles of analysis. Justification was required when the data team believed that the requested data were not required or that more data were requested than could be effectively analyzed.

Priorities were established for data reduction requirements to ensure some order in dispensing the available data. Some of the factors considered in establishing priorities were the importance of a quick solution to anomalies, the balance of data (i.e., one group of analysts not having more data than they could use while another group was waiting for data), and the availability of the range tapes or other data sources.

Data reduction was also enhanced by selecting the type of data processing output most applicable to the situation. By using their knowledge of the capabilities and the status of the processing equipment, the other data requirements in work, and the purpose of the analysis the data were to support, the data team could suggest alternates for the requested processing method. For example, an analyst (because of familiarity with the output) might request a tabular output of a few parameters for a long segment of the mission. After analyzing this request, the data team would recommend a stripchart-type output for these data. The basis for this recommendation was that, for the particular set of circumstances, the suggested output would be faster and more economical to produce and easier to scan and analyze. After a discussion of the situation, the analyst and the data team would agree on the method of data processing.

Planning for Missions

The first lunar-landing mission produced approximately 220 hours of spacecraft data from the two vehicles during the 195-hour mission. Because of the time and costs associated with the shipment of range tapes and the reduction of all mission data, a plan was required that would ensure that the evaluation could be accomplished without in-depth processing of all mission data. To achieve this objective, discussions were then held with the users to acquaint the data team with the analysis techniques and to educate the analyst on the potentials and limitations of the data processing systems.

The evaluation concept was based on the assumption that there would be long periods of routine operation, some planned periods of high interest activity, and some unplanned periods of high interest activity. To implement this concept, the objectives were to establish what constituted normal mission operations, to review each mission in sufficient detail to establish periods of special interest, and to reduce data for detailed analysis of these special interest periods.

As much as possible, all data outputs were planned before the mission. Measurements were placed in related groups (normally by subsystem) for ease of analysis. Tabulation, plot, and stripchart formats were specified.

Normal systems operating characteristics were established by analysis of data from tests and early Apollo flights. Because early unmanned flights were of short duration, most available data were processed. To aid in data validation and to acquaint the analyst with the strengths and weaknesses of the various output formats, the data were also processed and displayed in several different types of outputs.

As the Apollo Program progressed to longer duration flights, a quick-look technique was used to provide visibility into areas requiring further analysis. Data that were required for operational control of the mission were used in this technique. The initial data display was on a television screen in real time. These data were also processed into a hard-copy form, which was available within 4 to 12 hours after the data were received. In addition to developing a general concept for managing the data, the data management team developed several processing techniques to assist both the analysis and the processing workload.

Bandpass techniques. - The prime processing technique used for the Apollo Program was the bandpass tabulation. A bandpass tabulation is a display format that highlights those measurements with changing values. Repetitious data points are omitted, and only those measurements that change by a predetermined amount are tabulated. A bandpass technique is used in a PCM system because it does not produce a continuous indication of the measurement values; it produces discrete digital values (counts) at a predetermined sample rate. This system does not contain information between counts.

The simplest form of a bandpass technique scans the PCM counts transmitted and eliminates all redundant counts. This method prints out the first count value, holds this value in the computer memory, and compares each successive count to this base until there is a change. No repetitive values are retained. The changed count is printed and stored in the computer memory as the new base value. This technique is called a zero-count bandpass. Because all changes are printed and all transmitted data can be reconstructed by reinserting the redundant data points, no data are lost. A time history and a bandpass of the same data are given in table II.

TABLE II. - COMPARISON OF FULL RATE AND ZERO-COUNT BANDPASS DATA

Time, hr:min:sec	CC0206V Direct-current voltage main bus A	CC0207V Direct-current voltage main bus B
Full rate data		
105:47:50.083	28.29	28.09
105:47:50.183	28.29	28.09
105:47:50.283	28.29	28.09
105:47:50.383	28.29	28.09
105:47:50.483	28.29	28.09
105:47:50.583	28.10	28.09
105:47:50.683	28.10	28.09
105:47:50.783	28.10	28.09
105:47:50.883	27.92	27.91
105:47:50.983	27.92	27.91
105:47:51.083	27.92	27.74
105:47:51.183	27.92	27.74
105:47:51.283	28.10	27.74
105:47:51.383	28.10	27.74
105:47:51.483	28.10	27.74
[a]105:47:51.583	28.10	27.74
Zero-count bandpass data		
105:47:50.083	28.29	28.09
105:47:50.583	28.10	--
105:47:50.883	27.92	27.91
105:47:51.083	--	27.74
105:47:51.283	28.10	--
[a]105:47:51.583	28.10	27.74

[a]Last value of each data interval.

The zero-count bandpass technique has the advantage of deleting superfluous data. Because of long periods of quiescent system operations and because of measurements that by nature change slowly, approximately 80 percent of the returned data need not be presented to the analyst. A shortcoming of this technique is that a measurement that is noisy or rapidly changing between two counts results in an excessive output of useless data. This shortcoming can be corrected by opening the bandpass limits and eliminating the insignificant data. This method is feasible because the instrumentation system operates so that a one-count change is sufficient to provide data for off-nominal conditions. During normal operation, a change of several counts usually is not significant in the analysis process. Limits are defined as standard bandpass when the analysts and the data team have agreed that these limits are to be used in processing the majority of the data.

Manned Space Flight Network data usage. - Another technique developed for the Apollo Program involved taking the real-time data returned for mission control purposes and processing the data specifically for hardware evaluation. The method of displaying MSFN data was developed primarily for the lunar missions because there were long continuous periods of real-time data transmission during these missions.

As previously explained, the real-time operational data were transmitted from the receiving sites at a reduced sample rate. These data were displayed in various ways for ground support personnel. However, for postflight analysis purposes, the data were routed to the central data facility for processing. After zero-count bandpass processing, the data were stored in a computer memory. At regular intervals, the data were processed with a standard bandpass technique and tabulated or plotted for evaluation.

Although the MSFN data output provided processing for large amounts of data, the following constraints of the system were required.

1. Standard output formats would be established approximately 30 days before the mission.

2. The time contained in the data stream would be used uncorrected.

3. Measurements with two or more modes of calibration would be processed with the most common mode.

4. Only real-time data would be processed.

The MSFN data were available at 4-hour intervals in predetermined formats with preset bandpass limits. Two other options were available for limited use. One was the rapid processing (approximately 1 hour) of data from short time periods by special handling and priority during the processing cycle. The other option was the use of the zero-count bandpass technique also for short time periods. The requirement for assigning a computer for the duration of the mission was a disadvantage of processing MSFN data.

Special programs. - In general, the output of the processed data was a simple, straightforward presentation that was used by all analysts for evaluating both nominal and anomalous conditions. Some analysts required special computations for systems analysis. Two examples of different approaches used to meet this situation are discussed in the following paragraphs.

For the analysis of the reaction control system, standard analysis programs were developed. When special programs were required, standard computations that were not dependent on personal judgment were used. With this mode of data presentation, the basic system analysis was accomplished with data processed by the central computer facility; therefore, additional programs were not required.

For analysis of the ascent, descent, and service propulsion systems, however, the only reduced data provided were standard printouts of chamber pressure and other telemetered propulsion parameters. To comply with the requirement for special computations, a computer-compatible tape was provided to the MSC systems analysts for further reduction with their own computer programs. During this reduction, the analysts weighted the various measurements on the basis of results from ground tests and previous flight tests. Because this method of data reduction contained a judgment factor, these programs were unacceptable to other analysts who were either unfamiliar with the weighting factors or did not agree with the factors. Consequently, other analysts had to develop additional programs to evaluate these propulsion systems, which proved to be a continuing problem. A better solution for all analysts would have been to develop standard programs for special computations. Any additional computations involving personal judgment could have been made to supplement the standard output. This experience emphasized the need for an agreement on processing all data required for the basic analysis.

Data Management Aids

The data team developed several aids for the management task. As input to these aids, two types of daily teletype messages were required from each remote site. One contained the time periods of real-time data recorded at the site and identified the tape recorder. The other type of message furnished information on the data playbacks received by each site. The MSFN data furnished information on the data rate being transmitted by the spacecraft. The information provided by these data sources was used in three computer programs and served as a management aid for the data team.

Flight data source log. - The flight data source log listed all recorded telemetry tapes in time sequence generated during a mission. This log used information from the site teletype messages and listed the recording site, start and stop time of each tape, recorder number, type of recorded data (real time or delayed time), and accession number of all tapes delivered to MSC. This log was used primarily to identify a particular range tape to assure that it was sent to MSC. An example of this log is shown in figure 1.

SEQ NO.	RECORD STAT	TAPE NO.	DSS	GMT TIMES START	GMT TIMES STOP	YR	GET TIMES START	GET TIMES STOP	DATA TYPE	MISSION PHASE	REMARKS
355	ACN	15-0849	630	211/1849	211/1859	71	101:15	101:25	DCL	LO	REV 12
1220	DUMP	-------	---	211/1857	211/1946	71	101:23	102:12	L		MAD 634 LBR
933	DUMP	-------	---	211/1857	211/1947	71	101:23	102:13	C		MAD 633 LBR
356	ACN	15-0849	630	211/1942	211/1956	71	102:08	102:22	DCL	LO	REV 13
496	MAD	15-0619	631	211/1942	211/2027	71	102:08	102:53	CL	LO	REV 13
504	MAD*	15-0633	637	211/1949	211/2002	71	102:15	102:28	DCL	LO	REV 13
358	ACN	15-0850	630	211/1955	211/2033	71	102:21	102:59	DCL	LO	REV 13
497	MAD	15-0620	631	211/2026	211/2058	71	102:52	103:24	CL	LO	REV 13
360	ACN	15-0851	630	211/2032	211/2051	71	102:58	103:17	DCL	LO	REV 13
505	MAD*	15-0634	637	211/2032	211/2034	71	102:58	103:00	DC	LO	REV 13
506	MAD*	15-0634	637	211/2039	211/2042	71	103:05	103:08	DCL	LO	REV 13
507	MAD*	15-0635	637	211/2050	211/2059	71	103:16	103:25	DC	LO	REV 13
364	ACN	15-0852	630	211/2050	211/2058	71	103:16	103:24	DC	LO	REV 13
934	DUMP	-------	---	211/2112	211/2148	71	103:38	104:14	C		GDS 375 LBR
365	ACN	15-0852	630	211/2137	211/2152	71	104:03	104:18	DC	LO	REV 14

Notes: (1) SEQ NO. (sequence number) - A number assigned by the data manager for initial program entry.

(2) RECORD STAT (recording station) - Ground station that recorded data. (Dump is a manual entry to indicate delayed-time data coverage. Recording stations (Ascension (ACN), Madrid (MAD), or Goldstone (GDS)) are designated with an asterisk.)

(3) TAPE NO.- Number assigned by MSC after receipt of station tape.

(4) DSS (data service support) - Number assigned by network to designate mission phase and type of data-recorded tape (630 and 631 - real-time data for translunar coast and lunar orbit, 632 and 633 - real-time data for transearth coast, 637 - all delayed-time data).

(5) GMT TIMES - The Greenwich mean time for the data start and stop times.

(6) YR (year) - The year data were recorded.

(7) GET TIMES - The ground elapsed time for the data start and stop times.

(8) DATA TYPE - To indicate the vehicle downlink recorded on tape (C = CSM, L = LM, and D = DUMP).

(9) MISSION PHASE - LO = lunar orbit.

(10) REMARKS - REV 12, REV 13, and REV 14 indicate revolution number. MAD 634, MAD 633, and GDS 375 indicate the recording station and the last three digits of the tape number. LBR indicates a low bit rate dump

Figure 1.- Example of a portion of a flight data source log.

Request status maintenance report. - The request status maintenance report contained a listing of data requested and included information on the request number, time period, accession number of the tape used, and status of the requested data. Data were listed in a number of ways, but the most widely used method was listing by the time requested or the request number. This report was used to avoid duplication of requests, to provide processing status, and to assess priorities. A portion of this report is shown in figure 2.

APOLLO 15 REQUEST STATUS AS OF 0800 10/19/71

TIME START	(AET) STOP	REQ. NO.	SITE	B/R	DMP	C/L	SADQ/TE	BILEVEL	STD TAB	STD PLT	COMP WDS	SPL TAB	SPL PLT	BRSH CHT	O'GRAMS	LOOK ANG	EXP TAB	BIO MED	ANLG T/C	DIG T/C	VOIC T/C	PPS B/T	RCS B/T	EXP B/T	TRAJECT	MISCELL	REMARKS	TAPE NO.
101:09	101:23	634	MAD	H		C	C	C	C		C																	:00619
101:09	101:25	7041	MAD	H		C	D																				FORMAT 3.9KB/S PCM ONLY	:00619
101:20	102:12	545	MAD	L	D	C	C	C	C		C															C	CRYO TAPE	:00633
101:22	101:25	633	MAD	L		C	C	C	C		C																	:00619
101:23	102:13	6043	MAD	H	D	C	D																				FORMAT 64KB/S PCM ONLY	:00633
101:23	102:13	7042	MAD	H	D	C	D																				FORMAT 3.9KB/S PCM ONLY	:00633
101:38	101:45	403	MAD	L		C	C	C	C		C																COMPRESSED FULL-RATE	:00633
101:38	101:45	586	MAD	L	D	C	C																				FORMATTED ON REQ 403	:00633
102:08	102:53	6044	MAD	H		C	D																				FORMAT 64KB/S PCM ONLY	:00619
102:08	102:53	7043	MAD	H		C	D																				FORMAT 3.9KB/S PCM ONLY	:00619
102:12	102:28	722	MAD			C	C	C																				:00619
102:13	110:06	147	GOSS			C															C						15-03251,252,253,067,68,69,70,71	:MULTI
102:49	103:40	716	MAD	H		C	C				C																	:00620
102:52	103:24	6045	MAD	H		C	D																				FORMAT 64KB/S PCM ONLY	:00620
102:52	103:24	7044	MAD	H		C	D																				FORMAT 3.9KB/S PCM ONLY	:00620
103:00	103:25	632	MAD	H		C	C	C	C		C																	:00620
103:38	104:14	6038	GDS	H	D	C	D																				FORMAT 64KB/S PCM ONLY	:00376
103:38	104:31	7037	GDS	H	D	C	C																				FORMAT 3.9KB/S PCM ONLY	:00376
103:38	104:14	6037	GDS	H	D	C	D																				FORMAT 64KB/S PCM ONLY	:00375
103:38	104:14	7036	GDS	H	D	C	D																				FORMAT 3.9KB/S PCM ONLY	:00375
103:40	104:10	544	GDS	L	D	C	C	C	C		C															C	CRYO TAPE	:00375
104:03	104:33	6039	GDS	H		C	D																				FORMAT 64KB/S PCM ONLY	:00364

Notes: (1) TIME (AET) - Time of data on tape in elapsed time from nearest whole second before lift-off (same as GET in figure 1).

(2) REQ NO. - Number assigned to data request that initiated processing of data.

(3) SITE - Range station where tape was recorded (GOSS = ground operational support system).

(4) B/R - Bit rate of data: H = high bit rate, L = low bit rate.

(5) DMP - "D" indicates data from a dump of the onboard recorder.

(6) C/L - Indicates vehicle that is the data source: C = command and service module and L = lunar module.

(7) Remaining vertical columns - Various types of data outputs that are requested and processing status. One of the following designations appears in the column if that output has been requested: R = requested; C = completed; D = request deleted.

(8) TAPE NO. - Last five digits of accession number, which is the number assigned by MSC after receipt of range station tape.

Figure 2. - Example of a portion of a request status maintenance report.

Flight data source plot. - The flight data source plot was a time-line plot of all data recorded at the three deep-space tracking sites (Madrid, Spain; Honeysuckle, Australia; and Goldstone, California). Both real-time and delayed-time data were plotted, individual tapes were identified, and the transmitted data rate and selected mission events were indicated. The request status maintenance report printout for the same time period was usually published on the page facing the plot. The information for this plot was taken from the flight data source log, the request status maintenance report, the data rate from the MSFN data, and the manual inputs of mission events. A sample of this plot is shown in figure 3.

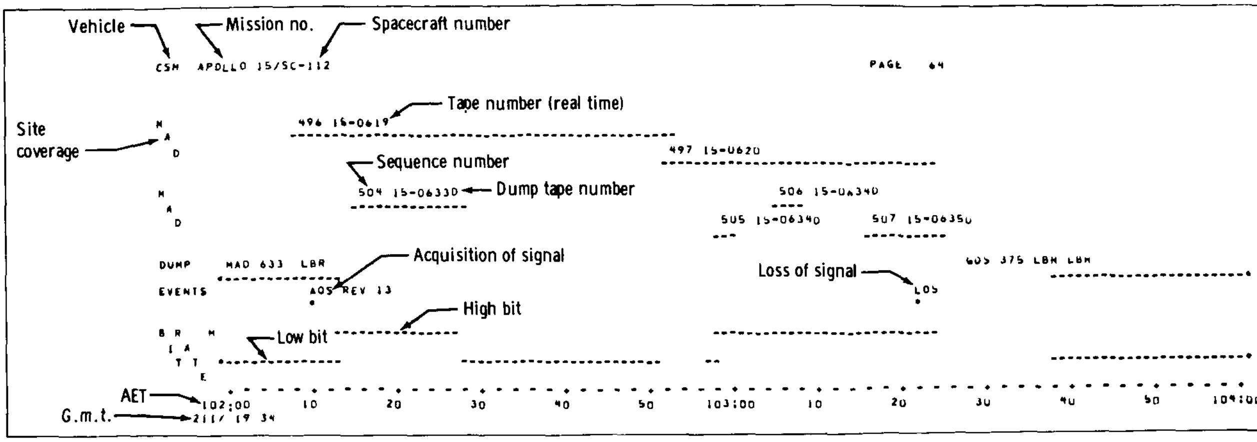

Figure 3. - Annotated page of flight data source plot.

Mission and Postmission Operations

The mission evaluation team supported the flight control team during the mission and conducted the postmission analysis. Three types of data were available to the analysts during the mission.

Television data. - Television data were available to the analysts from many closed-circuit television receivers in the mission evaluation room. These receivers displayed mission control data. The formats of these displays were established and controlled by the flight controllers. Most displays were grouped by subsystem, so that each analyst had data of his particular interest displayed. A Polaroid camera, controlled by the data manager, provided a limited hard-copy capability.

Summary messages. - Summary messages were distributed in the form of teletype transmissions. Each message was generated by a particular flight controller at his discretion and contained the telemetered values of preselected measurements at the requested time. These messages were received by the analyst within minutes of being produced and provided printed data points.

Manned Space Flight Network data. - The MSFN data were originated specifically for mission evaluation team use. The systems analysts reviewed these data and determined the areas in which more detailed analysis was required. Requests for postflight data from these areas were made to the data team.

The data team received these requests, combined them with requests from other analysts, ordered the range tape, and transmitted the data request to the selected processing organization. The data team reviewed the processing status daily and assigned priorities for data reduction. Priority assignments were based on the most impending problem facing the evaluation team, the availability of range tapes, and the need to maintain a balance of data among the analysts. After data processing, these data were validated and delivered to the users.

Data Validation

Data validation was required to ensure that no errors were introduced by the data processing equipment. Data validation identified suspect or erroneous information that was the result of ground processing or problems with the spacecraft instrumentation system. The validation process began with preflight readiness checks and continued through postflight evaluations.

The preflight task verified the entire processing system by comparing the reduced data with known input values with a specially prepared confidence tape. The tape was introduced into the system as early as possible.

For MSFN data, the validation consisted of transmitting the data by high-speed data lines from a remote-site data processor to MSC. The validation was conducted in parallel with the flight control operation for economy and early determination of transmission errors. Normal mission procedures were used in data processing. An additional check of the MSFN data processing was made by reviewing data reduced during the countdown demonstration test. This validation used actual spacecraft data and provided additional confidence in the processing system.

Range tape programs were validated with the confidence tape instead of the range tape, and normal postflight procedures were used in processing the data. All data outputs were verified for data grouping, arrangement, identification, timing, and data value. Additionally, the use of the correct calibration information was verified.

The postflight validation effort primarily consisted of comparing data from different processing methods to ensure the accuracy of these methods. For example, data processed with a computer were compared with the same data processed on stripcharts. All differences were resolved by the data team.

The prime aid used by the data group for determining data quality was the synchronization and data quality tabulation. This tabulation was made from the same tape used as an input for other processing and usually provided a good indication of the actual output quality. The designation of erroneous data and the cause of the error were indicated by this tabulation. With this information, data were sometimes recovered when special processing techniques were used.

During the processing of a data tape, data were sometimes missing for short periods of time. These time periods were indicated in the reduced data. Standard engineering troubleshooting techniques were used to determine and resolve instrumentation system problems.

CONCLUDING REMARKS

A central data management team with authority to approve and control data reduction greatly improves the capability to manage large amounts of data. The technique of processing only significant data is a necessity for economically evaluating space missions. The earlier this technique can be instituted in the gathering, transmitting, and processing system, the more advantageous it becomes. It is essential that preplanned, standardized, processing procedures be developed and used to process large amounts of data rapidly. All data required for basic systems evaluation should be processed with techniques understood by all analysts.

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APPENDIX

Glossary

Bit - a binary digit that has only two states, "0" or "1"; the smallest piece of information produced by a PCM system

Computer-compatible tape - a digital magnetic tape produced by a computer for direct use by another computer

Frame - that portion of a PCM bit stream between successive synchronization patterns

In depth - a detailed analysis of data

Output - the final presentation of a computer program

Playback - the retrieval of data from a magnetic recorder

Prime frame - see frame

Quick look - a rapid or cursory evaluation of data or data processed quickly to facilitate a rapid evaluation

Real time - at the same time the event is occurring

Stripchart - a data presentation technique in which measurements are presented as a continuous line on a paper strip; oscillograms and pen recordings are two common types of stripcharts

Subframe - the portion of a PCM bit stream between successive samples of those measurements that have the lowest sample rate

Word - the number of PCM bits assigned to each particular measurement; usually, in one bit stream, there is a standard word length

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